PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventor RONALD HENRY CHAPLIN

899,862

Date of filing Complete Specification Jan. 10, 1961.

Application Date Oct. 30, 1959. *No. 37008/59*

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Index at acceptance:—Class 4. A5. C(5D:5X:7A1:7B3). H1A.

Inter

ERRATUM

SPECIFICATION No. 899,862

Page 1, in the heading, *for* "Inventor: Ronald Henry Chaplin" *read* "Inventor: Roland Henry Chaplin"

THE PATENT OFFICE
21st December 1962

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the subject of Patent No. 861,480 which aircraft included a gas turbine mounted within the fuselage at or about the centre of gravity of the aircraft, the gas turbine having associated therewith a pair of nozzles situated forward of the centre of gravity and a second pair of nozzles situated aft of the centre of gravity, the nozzles comprising each pair projecting from the fuselage on opposite sides, the forward pair of nozzles discharging air bled from the compressor of the gas turbine, the aft pair of nozzles discharging efflux gases from the turbine, the nozzles being mounted for simultaneous orientation, whereby the whole volume of air and efflux gases discharged from the four nozzles could be directed rearwardly and used for forward propulsion or directed downwardly to produce vertical or otherwise upward lift.

Furthermore it is preferred that the nozzles shall be capable of movement beyond a vertical position in a forward direction, the angular movement of the nozzles being in the region of 100°, whereby the thrust from the nozzles can be directed in a downward and slightly forward direction during the transition

mal forward flight where the thrust from the four nozzles will still be providing the greater part of the lift but the aircraft as a result of the orientation of the nozzles is building up forward speed, during which period the wings and tail surfaces are gradually taking over the lift.

It is, of course essential that the speed of orientation of the nozzles in that direction shall be carefully controlled, orientation being progressive but slow, but conversely during the transition stage between forward flight and hovering or vertical flight, for example flight in a downward vertical direction, orientation shall be rapid from the point of view of first slowing up the aircraft and then, after the speed has fallen to near stalling speed, taking over the lift, the downward thrust from the nozzles finally taking the whole weight of the aircraft.

The invention consists broadly in the provision of a control mechanism in an aircraft as hereinbefore defined which when operated will automatically slow down the speed of orientation of the nozzles from a vertical or near vertical position to a horizontal position and

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International Classification:—B64c, d.

COMPLETE SPECIFICATION

Improvements in Aircraft Control Mechanism

We, HAWKER AIRCRAFT LIMITED, a British Company, of Richmond Road, Kingston-upon-Thames, in the County of Surrey, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to control mechanism for aircraft of the vertical take-off and landing type, the phrase being intended to cover fixed wing aircraft which are either capable of taking off and landing at a steep angle and at a speed below stalling speed.

The invention is particularly concerned with the type of fixed wing aircraft forming the subject of Patent No. 861,480 which aircraft included a gas turbine mounted within the fuselage at or about the centre of gravity of the aircraft, the gas turbine having associated therewith a pair of nozzles situated forward of the centre of gravity and a second pair of nozzles situated aft of the centre of gravity, the nozzles comprising each pair projecting from the fuselage on opposite sides, the forward pair of nozzles discharging air bled from the compressor of the gas turbine, the aft pair of nozzles discharging efflux gases from the turbine, the nozzles being mounted for simultaneous orientation, whereby the whole volume of air and efflux gases discharged from the four nozzles could be directed rearwardly and used for forward propulsion or directed downwardly to produce vertical or otherwise upward lift.

Furthermore it is preferred that the nozzles shall be capable of movement beyond a vertical position in a forward direction, the angular movement of the nozzles being in the region of 100°, whereby the thrust from the nozzles can be directed in a downward and slightly forward direction during the transition stage between forward flight and hovering or downward flight preparatory to landing.

The present invention is concerned with the orientation of the nozzles during the transition stage between vertical take-off or take-off at an abnormally steep angle and forward flight and conversely between forward flight and hovering or downward flight, for example for landing purposes.

It will be appreciated that when taking off vertically or at a speed well below stalling speed the wing and tail surfaces of the aircraft will not to any material extent contribute to the lift and consequently the aircraft must necessarily pass through a transition stage between vertical or near vertical flight and normal forward flight where the thrust from the four nozzles will still be providing the greater part of the lift but the aircraft as a result of the orientation of the nozzles is building up forward speed, during which period the wings and tail surfaces are gradually taking over the lift.

It is, of course essential that the speed of orientation of the nozzles in that direction shall be carefully controlled, orientation being progressive but slow, but conversely during the transition stage between forward flight and hovering or vertical flight, for example flight in a downward vertical direction, orientation shall be rapid from the point of view of first slowing up the aircraft and then, after the speed has fallen to near stalling speed, taking over the lift, the downward thrust from the nozzles finally taking the whole weight of the aircraft.

The invention consists broadly in the provision of a control mechanism in an aircraft as hereinbefore defined which when operated will automatically slow down the speed of orientation of the nozzles from a vertical or near vertical position to a horizontal position and

conversely will produce a rapid orientation of the nozzles from the horizontal to a vertical or near vertical position.

The control preferably takes the form of an hydraulic damper, dash pot or the like which operates to slow down orientation in the one direction but is inoperative in the opposite direction.

It is preferred that orientation of the nozzles shall be instigated by the pilot and through the medium of a hand operated lever in the cockpit, the pilot operated mechanism taking the form of a control box.

Referring to the accompanying drawings:

Figure 1 is a fragmentary side elevation of an aircraft exemplifying the present invention;

Figure 2 is a plan view;

Figure 3 is a fragmentary perspective view diagrammatically illustrating one method of orienting the nozzles;

Figure 4 is a perspective view of the pilot's control mechanism for orienting the nozzles;

Figure 5 is a sectional side elevation of the control mechanism; and

Figures 6 and 7 are sectional views on the lines A—A and B—B in Figure 5.

The invention will now be described in detail in its application to an aircraft of the kind disclosed by the specification and drawings of Patent No. 861,480, the aircraft being fitted with a gas turbine, the casing of which is diagrammatically shown and indicated by reference numeral 1, the gas turbine being arranged at or about the centre of gravity of the aircraft and having a pair of nozzles 2 situated forward of the centre of gravity and a second pair of nozzles 2*a* situated aft of the centre of gravity, the forward pair of nozzles 2 discharging air delivered by a fan or compressor of the gas turbine, the aft pair of nozzles 2*a* discharging efflux gases from the turbine, the nozzles being mounted for simultaneous orientation through pipe couplings 3 which permit orientation of the nozzles through an angle of at least 90° although this movement may be increased to as much as 180° to provide the maximum amount of forward thrust for braking purposes. In the arrangement shown however, in Figure 1 the nozzles are arranged for simultaneous orientation through an angle of 100°.

To stabilise the aircraft during vertical take off and at other times when the control surfaces are ineffective downwardly directed control nozzles are provided at or near the nose and tail and at the wing tips, and air is bled to these nozzles from the compressor. Such control nozzles however form no part of the present invention, the present invention being concerned primarily with the controlled movement of nozzles 2 and 2*a*.

Any suitable means may be employed for connecting the two pairs of the nozzles together so that they can be orientated simultaneously but as the nozzles are naturally widely spaced both lengthwise and widthwise of the aircraft it is preferred to employ some such means which will operate satisfactorily where there is a substantial expansion of the gas turbine casing both lengthwise and widthwise of the aircraft.

One suggested method of orientating the nozzles is shown in Figure 3 consisting of an air motor 4 driving an articulated shaft 5 having a geared connection with transverse shafts 6 and 7 fitted with sprocket wheels 8 which in the case of the rear nozzles are connected directly by means of chains 9 with the rear nozzles, chains 9*a* in the case of the forward pair of nozzles 2 being connected with additional sprockets 8*a* carried by shafts 10, carrying sprocket wheels 8*b* which in turn are connected with the front nozzles by chains 9*b*.

Referring now to Figures 4 to 7 which illustrate a preferred form of pilot's control for orientating the nozzles in the desired direction, the control consists of a casing 11 having a main gate 12 for movement of the main control lever 13 and a subsidiary gate 14 for movement of a manual override and follow up lever 15.

The latter as its name implies follows up the movement of lever 13 in either direction and also provides a manual override for use in an emergency if for any reason the pilot wishes to increase the speed of orientation of the nozzles in the one direction over and above the speed determined by the dash pot or the like, the operation of which is about to be described.

The gate 12 contains a preselector stop 16 which can be set to limit movement of the lever 13 in one direction thereby limiting the angle of orientation of the nozzles in that direction.

The casing is calibrated as shown to give a visual indication of the angular position of the nozzles obtained as a result of a particular movement of the preselector stop 16.

A flexible control 26 connects the levers 13 and 15 with the controls of the air motor 4.

It will be appreciated that the angular positioning of the nozzles will depend upon the particular flight path chosen by the pilot.

In Figure 4 the full line position of lever 13 corresponds with that assumed during normal forward flight without the nozzles directly producing upward lift. The dotted line position of lever 15 is the position into which the lever would be moved to provide direct upward lift from the nozzles and a braking effect, as for example during the transition stage between forward flight and hovering or vertical landing.

Assuming therefore that lever 13 has been set for take-off, for example at the 90° position or thereabouts according to wind or other conditions or at any other angular position between the 90° position and zero for an ab-

normally steep angle of take-off, the pilot after taking off and wishing to assume normal forward flight will move lever 13 to the full line position at the zero end of the gate. Orientation of the nozzles will however be slow as orientation will be controlled by the dash pot.

On the other hand assuming the aircraft is in normal level forward flight and it is required to hover or make a vertical landing the pilot will first of all move lever 13 from the full line position to the dotted position, i.e. 100° to slow down the aircraft with the braking effect of the nozzles. Orientation of the nozzles will in this case occur quickly as the dash pot will be inoperative. When the aircraft speed has dropped sufficiently, lever 13 is then moved forward to 90° or thereabouts to bring the nozzles to the direct upward lift position.

The follow up lever in both cases will give a visual indication of the nozzle position and consequently when orientation is being controlled by the dash pot the pilot in an emergency can increase the rate of orientation by operation of lever 15.

The markings on the casing adjacent the gates indicate the angular position of the nozzles relative to the horizontal, the nozzles when the lever 13 is in the full line position facing aft at zero degrees and when the lever is in the dotted line position occupying a position in which they are directed downwardly and forwardly at an angle of 100° to the horizontal. Movement of the lever 13 from the full to the dotted line position will produce a quick orientation of the nozzles as is necessary for the transition stage between forward and vertical flight, movement in the opposite direction of the lever providing a slow orientation of the nozzles during the transition stage between vertical and forward flight, the speed being increased if necessary by operation of the manual override lever 15.

Turning now to Figures 5 to 7 of the drawings which illustrates in detail the pilot's control illustrated by Figure 4, levers 13 and 15 are pivotally mounted about a common fulcrum point 17 in the casing 11. Lever 13 has a pin and slot connection 18 with a frame 19; the parallel side members of which are formed with longitudinally arranged slots 20.

The side members are connected at one end by a transverse pin 21 and engage shorter pins 22 at their opposite ends. Pins 21 and 22 pass through slots 20.

Pins 21 and 22 pass through slots 23 in the walls of a tubular inner casing 24 having a bearing 25 at one end for the inner component of the control 26.

The inner casing 24 at its opposite end carries a piston rod 27 having a piston 28 sliding in a cylinder 29 rigidly associated with a tubular member 30 slidably mounted in the inner casing 24 and formed with slots 31 in its walls for the passage of pins 21 and 22.

Cylinder 29 contains air or a hydraulic fluid and is provided with sealing glands 32 at its opposite ends through which the piston rod 27 passes.

Pin 21 passes through a plug 33 which engages one end of a helical compression spring 34, the opposite end of the latter engaging a second plug 35 carrying the pins 22 and bearing on a shoulder on the member 30. Plug 33 also engages a closure gap closing the opposite end of member 30.

Piston 28 is so constructed that there will be a free flow of fluid past the piston in the direction of the arrow but a restricted flow in the opposite direction to provide the required damping effect.

Lever 15 has a pivotal connection 36 with an arm 37 on a yoke 38 having inwardly directed pins 39 passing through longitudinal slots (not shown) in casing 24 and engaging member 30. In this way follow up lever 15 will follow up endwise movement of the member 30 under the control of the dash pot device but can be moved manually to override the action of the dash pot and actuate the control 26 directly if required.

Lever 13 is provided with the usual spring urged pin engagement with a series of notches in the gate, the lever being freed by pressing it in a downward direction. A similar arrangement is provided in the case of the pre-set knob 16.

During for example take-off and for the transition stage between vertical and forward flight, lever 15 will be moved to the left in Figure 5. This compresses spring 34 and starts a slow flow of fluid past the piston with a consequential slow axial movement of member 30 and flexible control 26 which produces a slow orientation of the nozzles. If the lever is moved over to the right the fluid can pass the piston freely and consequently the nozzles will be oriented through the selected angle immediately.

WHAT WE CLAIM IS:—

1. Control mechanism in an aircraft of the vertical take-off and landing type as hereinbefore defined and of the kind in which vertical lift and forward propulsion are obtained by efflux nozzles capable of orientation between horizontal and vertical or near vertical positions, which control mechanism is provided for effecting such orientation, which mechanism when operated will bring about a slow speed of orientation from a vertical or near vertical position to a horizontal position and conversely will produce a rapid orientation of the nozzles from the horizontal to a vertical or near vertical position.

2. Control mechanism as claimed in Claim 1, including a control lever movable in either direction according to the required direction of orientation and a dash pot or its equivalent

normally steep angle of take-off, [illegible]ilot after taking off and wishing to assum[illegible]ormal forward flight will move lever 13 to the full line position at the zero end of the gate. Orientation of the nozzles will however be slow as orientation will be controlled by the dash pot.

On the other hand assuming the aircraft is in normal level forward flight and it is required to hover or make a vertical landing the pilot will first of all move lever 13 from the full line position to the dotted position, i.e. 100° to slow down the aircraft with the braking effect of the nozzles. Orientation of the nozzles will in this case occur quickly as the dash pot will be inoperative. When the aircraft speed has dropped sufficiently, lever 13 is then moved forward to 90° or thereabouts to bring the nozzles to the direct upward lift position.

The follow up lever in both cases will give a visual indication of the nozzle position and consequently when orientation is being controlled by the dash pot the pilot in an emergency can increase the rate of orientation by operation of lever 15.

The markings on the casing adjacent the gates indicate the angular position of the nozzles relative to the horizontal, the nozzles when the lever 13 is in the full line position facing aft at zero degrees and when the lever is in the dotted line position occupying a position in which they are directed downwardly and forwardly at an angle of 100° to the horizontal. Movement of the lever 13 from the full to the dotted line position will produce a quick orientation of the nozzles as is necessary for the transition stage between forward and vertical flight, movement in the opposite direction of the lever providing a slow orientation of the nozzles during the transition stage between vertical and forward flight, the speed being increased if necessary by operation of the manual override lever 15.

Turning now to Figures 5 to 7 of the drawings which illustrates in detail the pilot's control illustrated by Figure 4, levers 13 and 15 are pivotally mounted about a common fulcrum point 17 in the casing 11. Lever 13 has a pin and slot connection 18 with a frame 19; the parallel side members of which are formed with longitudinally arranged slots 20.

The side members are connected at one end by a transverse pin 21 and engage shorter pins 22 at their opposite ends. Pins 21 and 22 pass through slots 20.

Pins 21 and 22 pass through slots 23 in the walls of a tubular inner casing 24 having a bearing 25 at one end for the inner component of the control 26.

The inner casing 24 at its opposite end carries a piston rod 27 having a piston 28 sliding in a cylinder 29 rigidly associated with a tubular member 30 slidably mounted in the inner casing 24 and formed with [illegible]1 in its walls for the passage of pins 2[illegible] 22.

Cylinder 29 contains air or a hydraulic fluid and is provided with sealing glands 32 at its opposite ends through which the piston rod 27 passes.

Pin 21 passes through a plug 33 which engages one end of a helical compression spring 34, the opposite end of the latter engaging a second plug 35 carrying the pins 22 and bearing on a shoulder on the member 30. Plug 33 also engages a closure gap closing the opposite end of member 30.

Piston 28 is so constructed that there will be a free flow of fluid past the piston in the direction of the arrow but a restricted flow in the opposite direction to provide the required damping effect.

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Lever 13 is provided with the usual spring urged pin engagement with a series of notches in the gate, the lever being freed by pressing it in a downward direction. A similar arrangement is provided in the case of the pre-set knob 16.

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WHAT WE CLAIM IS:—

1. Control mechanism in an aircraft of the vertical take-off and landing type as hereinbefore defined and of the kind in which vertical lift and forward propulsion are obtained by efflux nozzles capable of orientation between horizontal and vertical or near vertical positions, which control mechanism is provided for effecting such orientation, which mechanism when operated will bring about a slow speed of orientation from a vertical or near vertical position to a horizontal position and conversely will produce a rapid orientation of the nozzles from the horizontal to a vertical or near vertical position.

2. Control mechanism as claimed in Claim 1, including a control lever movable in either direction according to the required direction of orientation and a dash pot or its equivalent

brought into operation by movement of the lever when the latter is moved to give a slow orientation.

3. Control mechanism as claimed in Claim 2, including a gate in which the lever moves, the gate being calibrated to show different angles of orientation of the nozzles and a preselector stop in the gate which can be set to limit angular movement of the lever in the direction which will produce a quick orientation of the nozzles.

4. Control mechanism as claimed in Claim 2 or 3, including an override and follow up lever which is operable if required to increase the speed of orientation or for use in an emergency in the event of the dash pot or its equivalent not operating efficiently.

5. Control mechanism as claimed in any of the preceding claims, including a dash pot consisting of a cylinder containing a piston and hydraulic fluid, the piston being so constructed that it allows free flow of fluid in one direction past the piston but only a restricted flow in the opposite direction.

6. Control mechanism as claimed in any of the preceding claims, including a flexible control member movable by the control lever and controlling the rotational direction of an air motor driving the nozzles through a system of driving chains and sprocket wheels.

7. Control mechanism for the purpose specified in an aircraft as defined substantially as described with reference to the accompanying drawings.

For the Applicants:
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PROVISIONAL SPECIFICATION

Improvements in Aircraft

We, HAWKER AIRCRAFT LIMITED, a British Company, of Richmond Road, Kingston-upon-Thames, in the County of Surrey, do hereby declare this invention to be described in the following statement:—

This invention relates to aircraft of the vertical take-off and landing type, the phrase being intended to cover fixed wing aircraft which are either capable of taking off and landing vertically, or alternatively taking off and landing at a steep angle and at speed below stalling speed.

The invention is particularly concerned with the type of fixed wing aircraft forming the subject of Patent No. 861,480 which aircraft included a gas turbine mounted within the fuselage, the gas turbine having associated therewith a pair of nozzles situated forward of the centre of gravity and a second pair of nozzles situated aft of the centre of gravity, the nozzle comprising each pair projecting from the fuselage on opposite sides, the forward pair of nozzles discharging air bled from the compressor of the gas turbine, the aft pair of nozzles discharging efflux gases from the turbine, the nozzles being mounted for simultaneous orientation, whereby the whole volume of air and efflux gases discharged from the four nozzles could be directed rearwardly and used for forward propulsion or directed downwardly to produce vertical or otherwise upward lift.

Furthermore it is preferred that the nozzles shall be capable of movement beyond a vertical position in a forward direction, the angular movement of the nozzles being in the region of 100°, whereby the thrust from the nozzles can be directed in a downward and slightly forward direction during the transition stage between forward flight and hovering or downward flight preparatory to landing.

The present invention is concerned with the orientation of the nozzles during the transition stage between vertical take-off or take-off at an abnormally steep angle and forward flight and hovering or downward flight, for example for landing purposes.

It will be appreciated that when taking off vertically or at a speed well below stalling speed the wings and tail surfaces of the aircraft will not to any material extent contribute to the lift and consequently the aircraft must necessarily pass through a transition stage between vertical or near vertical flight and normal forward flight where the thrust from the four nozzles will still be providing the greater part of the lift but the aircraft as a result of orientation of the nozzles is building up forward speed, during which period the wings and tail surfaces are gradually taking over the lift.

It is, of course, essential that the speed of orientation of the nozzles in that direction shall be carefully controlled, orientation being progressive but slow, but conversely during the transition stage between forward flight and hovering or vertical flight, for example flight in a downward vertical direction, orientation shall be rapid from the point of view of first slowing up the aircraft and then, after the speed has fallen to near stalling speed, taking over the lift, the downward thrust from the nozzles finally taking the whole weight of the aircraft.

The invention consists broadly in the provision of a control mechanism which when operated will automatically slow down the speed of orientation of the nozzles from a vertical or near vertical position to a horizontal position and conversely will produce a rapid orientation of the nozzles from the

horizontal to a vertical or near vertical position.

The control preferably takes the form of an hydraulic damper, dash pot or the like which operates to slow down orientation in the one direction but is inoperative in the opposite direction.

It is preferred that orientation of the nozzles shall be instigated by the pilot and through the medium of a hand operated lever in the cockpit, the pilot operated mechanism taking the form of a control box.

The box consists of a main control lever, a follow up lever which can also be used by the pilot as an emergency override and a preselector stop. The main control lever is locked in a number of set positions and released by means of a hand pressure on the top of the lever, both levers operating in a gate which is marked to give the pilot a visual indication of the angular position of the nozzles obtained as a result of a particular movement of the selector stop.

It will be appreciated that the angular positioning of the nozzles will depend upon the particular flight path chosen by the pilot.

The pilot wishing to alter the position of the nozzles carries out the following operations:

1. Move the preselector stop to the required nozzle position. This can be done at the pilot's convenience.
2. At the required instant that the nozzles are to be rotated the main control lever is slammed back against the stop and is automatically locked into position. The pilot can do this without looking. No matter how fast the lever is moved for the slow rate of rotation the damper takes charge to give the necessary rate.
3. The follow up lever gives a visual indication of the nozzle position and in an emergency allows the pilot to override or overcome and sticking in the damper or to increase the rate of rotation if necessary.

The two levers preferably move in a quadrant gate. Movement of the main control lever in one direction will result in slow pivotal movement of the nozzles in an upward direction whilst movement of the lever in the opposite direction will produce a quick pivotal movement of the nozzles in a downward direction.

Simultaneous orientation of the nozzles is preferably produced by means of an air motor which rotates the nozzles through a system of shafts, chains and chain sprockets, delivery of air to the motor being brought about by means of a control valve controlling the admission of air to the motor and the direction of rotation, which control valve is actuated by a flexible control member from the main control lever, the damper being interposed so that despite quick movement of the control lever in the one direction, the control valve will be only partially opened to bring about slow rotation of the air motor and consequently slow orientation of the nozzles, but on movement of the control lever in the opposite direction will be ineffective, thus permitting the maximum supply of air to the air motor to rotate the latter at maximum speed but in the reverse direction. Suitable speeds for orientation of the nozzles are thought to be in the region of 90° per second and 3°—5° per second.

Any suitable form of damper may be used but it is preferred to employ a form of hydraulic damper of the spring controlled type, the damper acting directly in one direction but producing a spring controlled damped movement in the opposite direction.

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London, W.C.2.

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Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

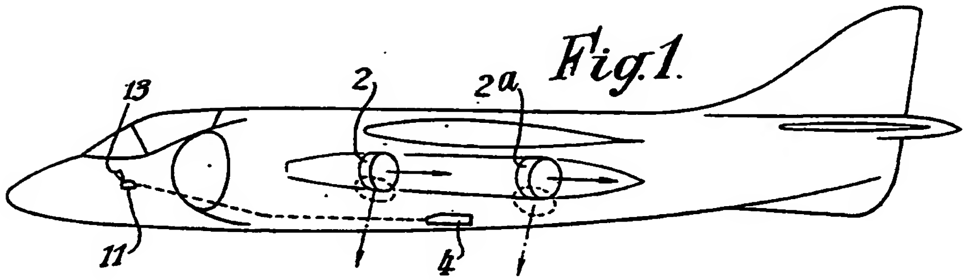


Fig.1.

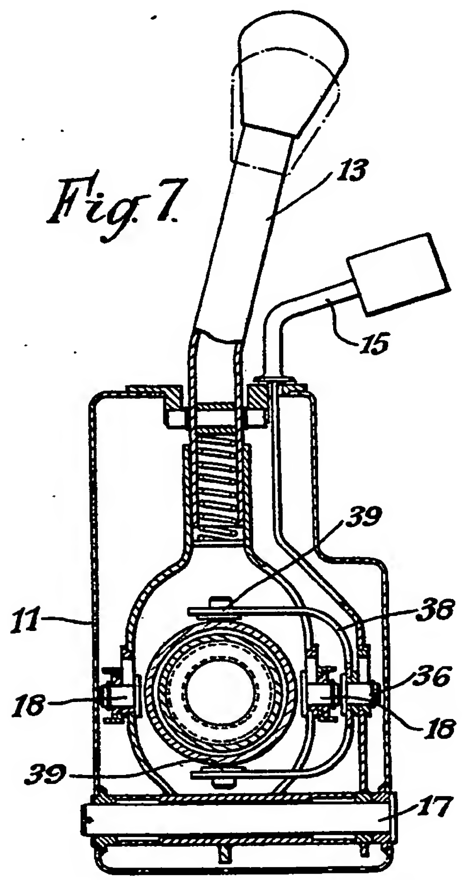


Fig.7.

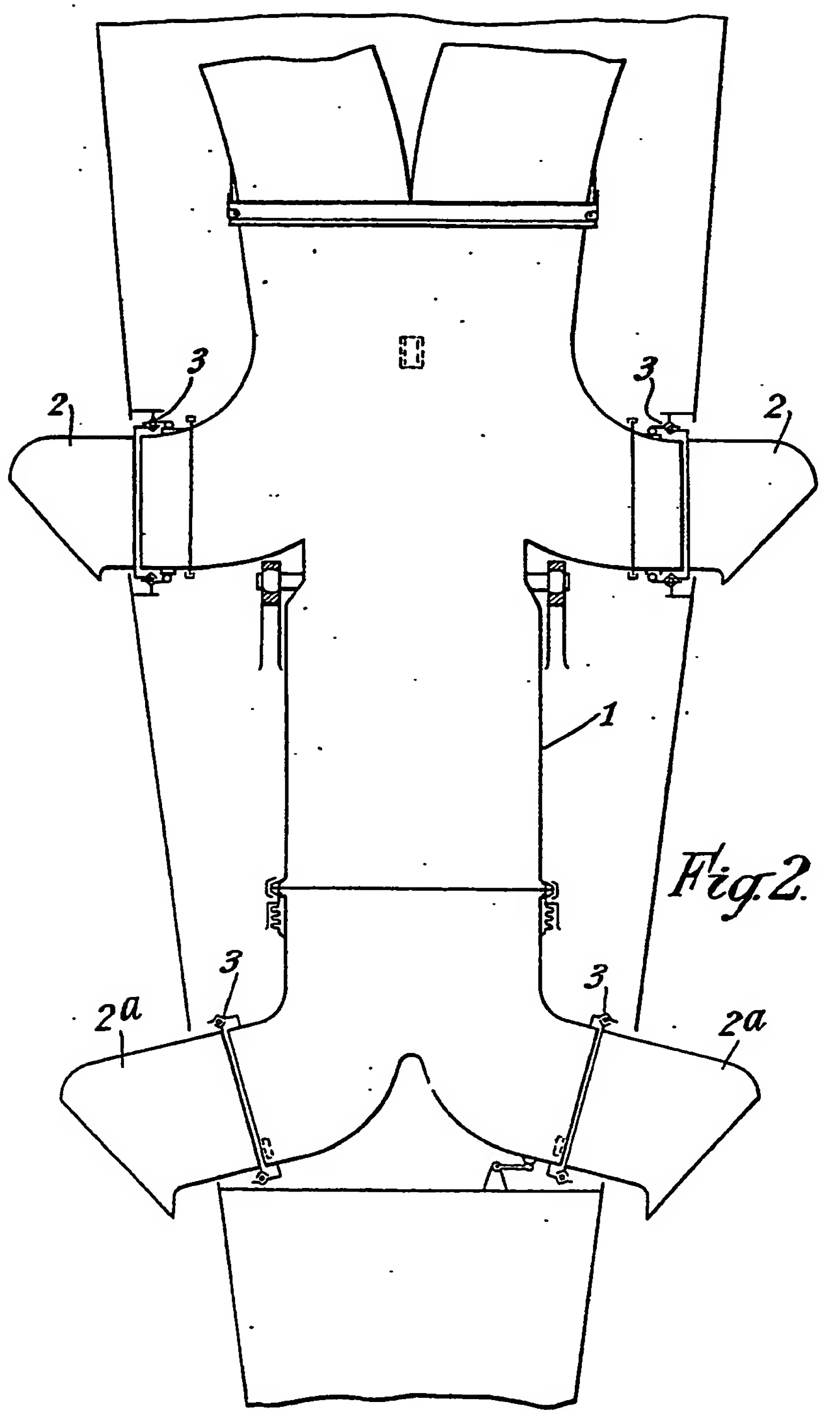
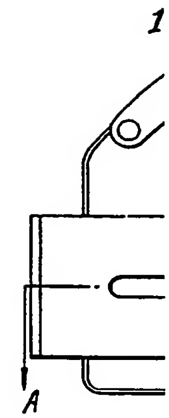
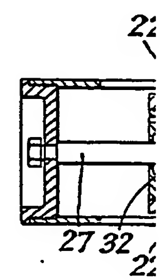


Fig.2.





899862 COMPLETE SPECIFICATION

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Sheets 2 & 4

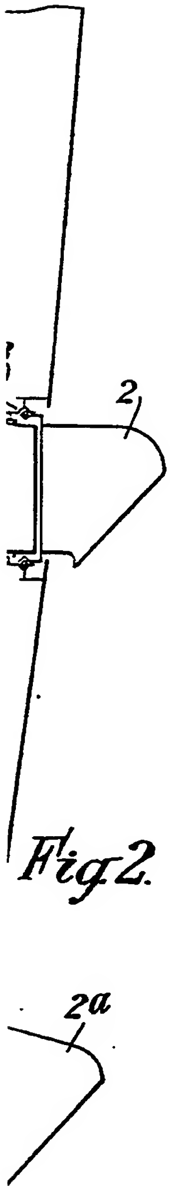

Fig.2.

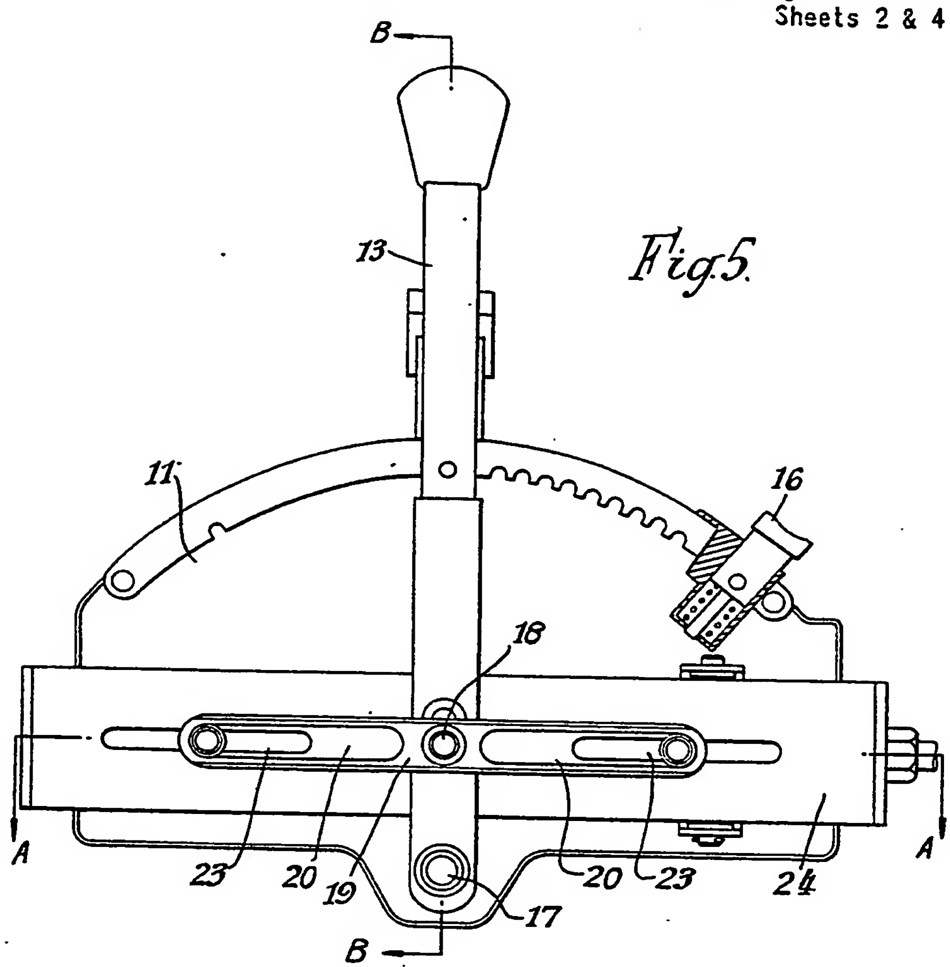

Fig.5.

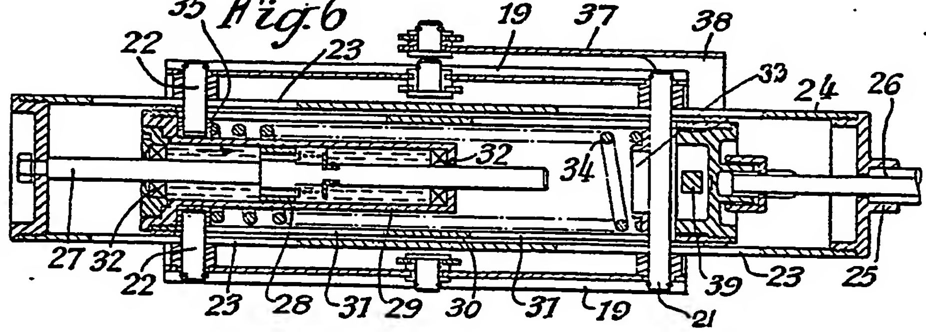

Fig.6

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Sheets 2 & 4

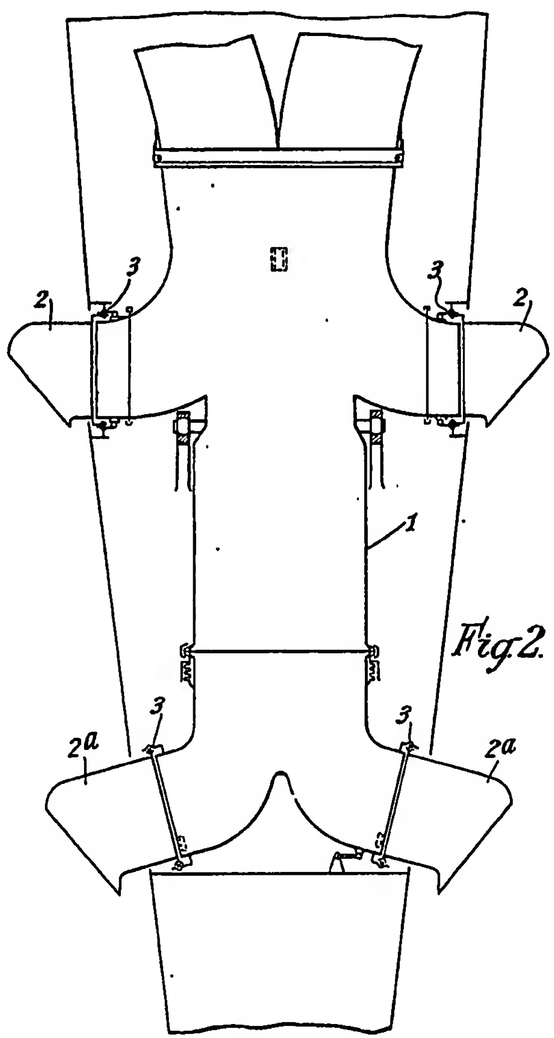


Fig.2.

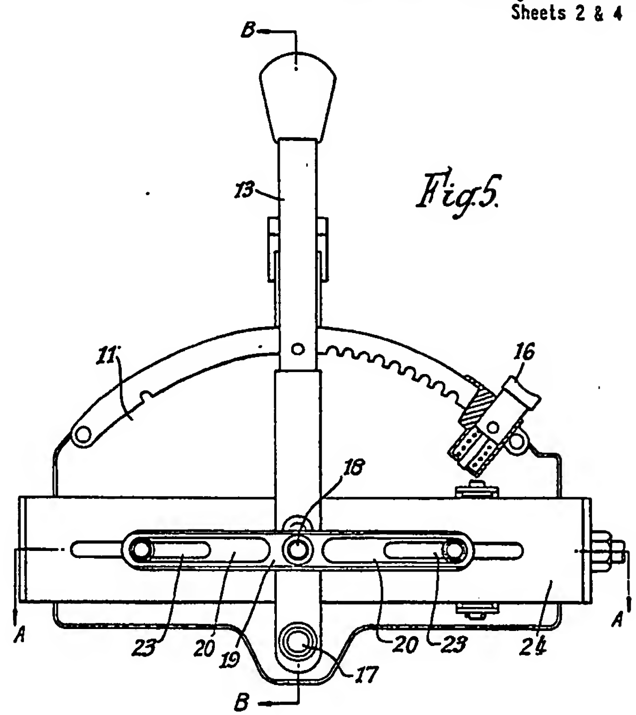


Fig.5.

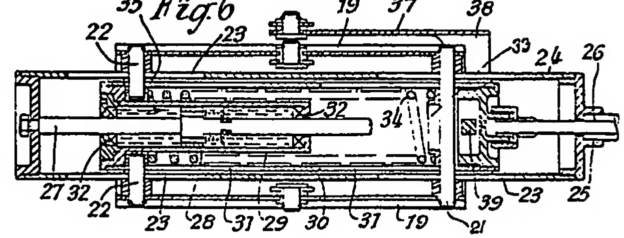
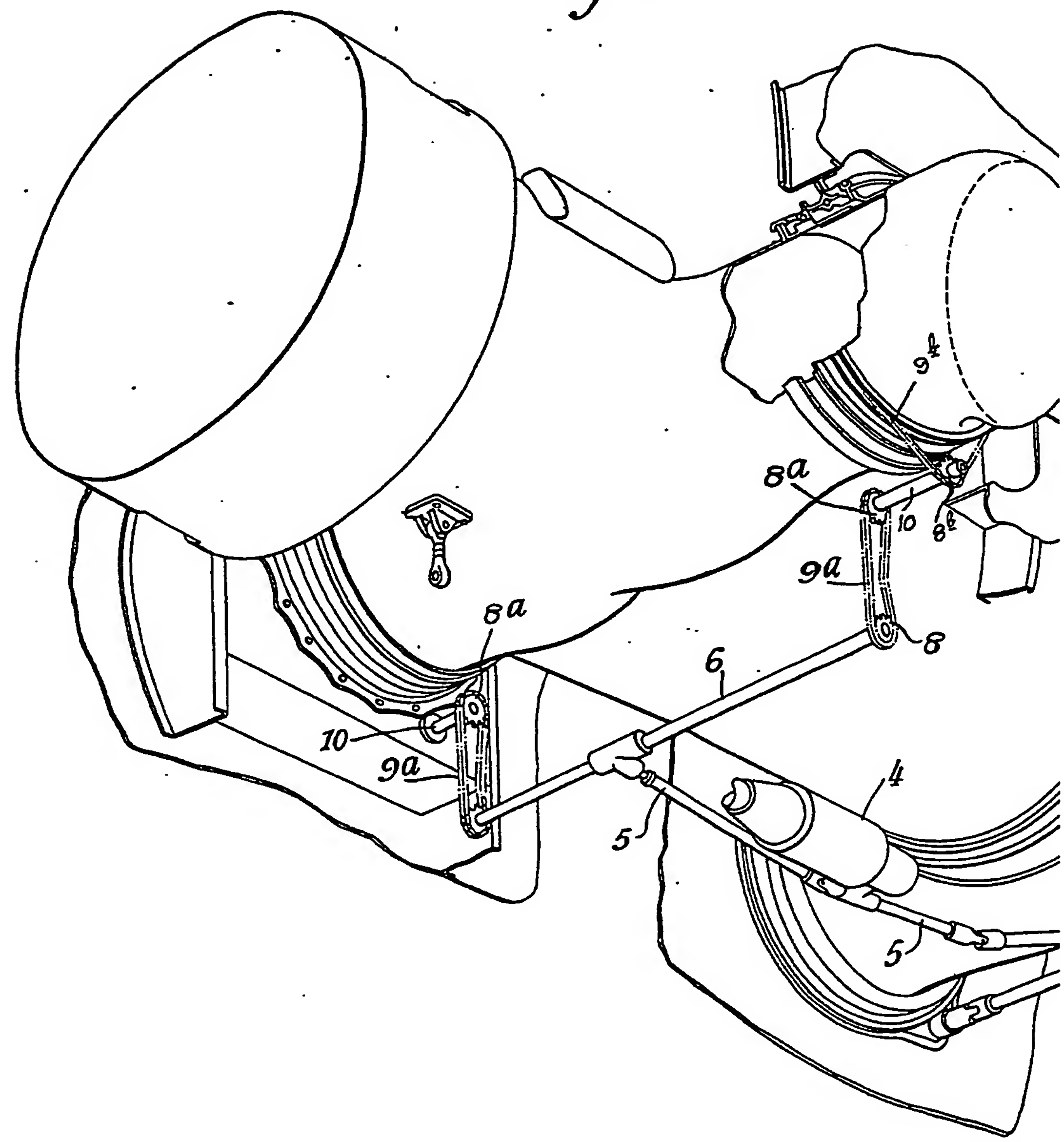


Fig.6

Fig. 3.



899862 COMPLETE SPECIFICATION

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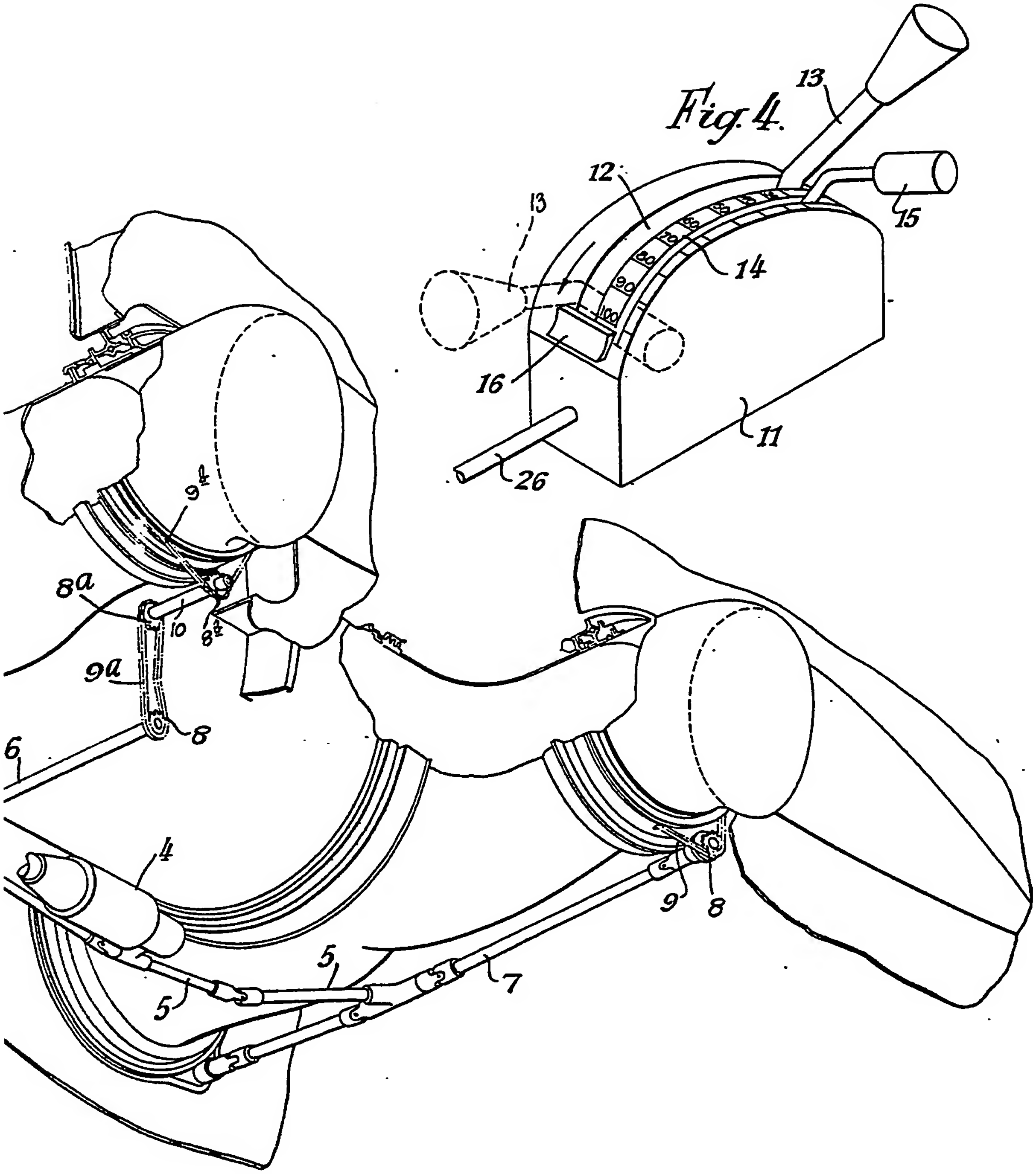
Sheet 3

Fig. 4.



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Sheet 3

Fig. 3.

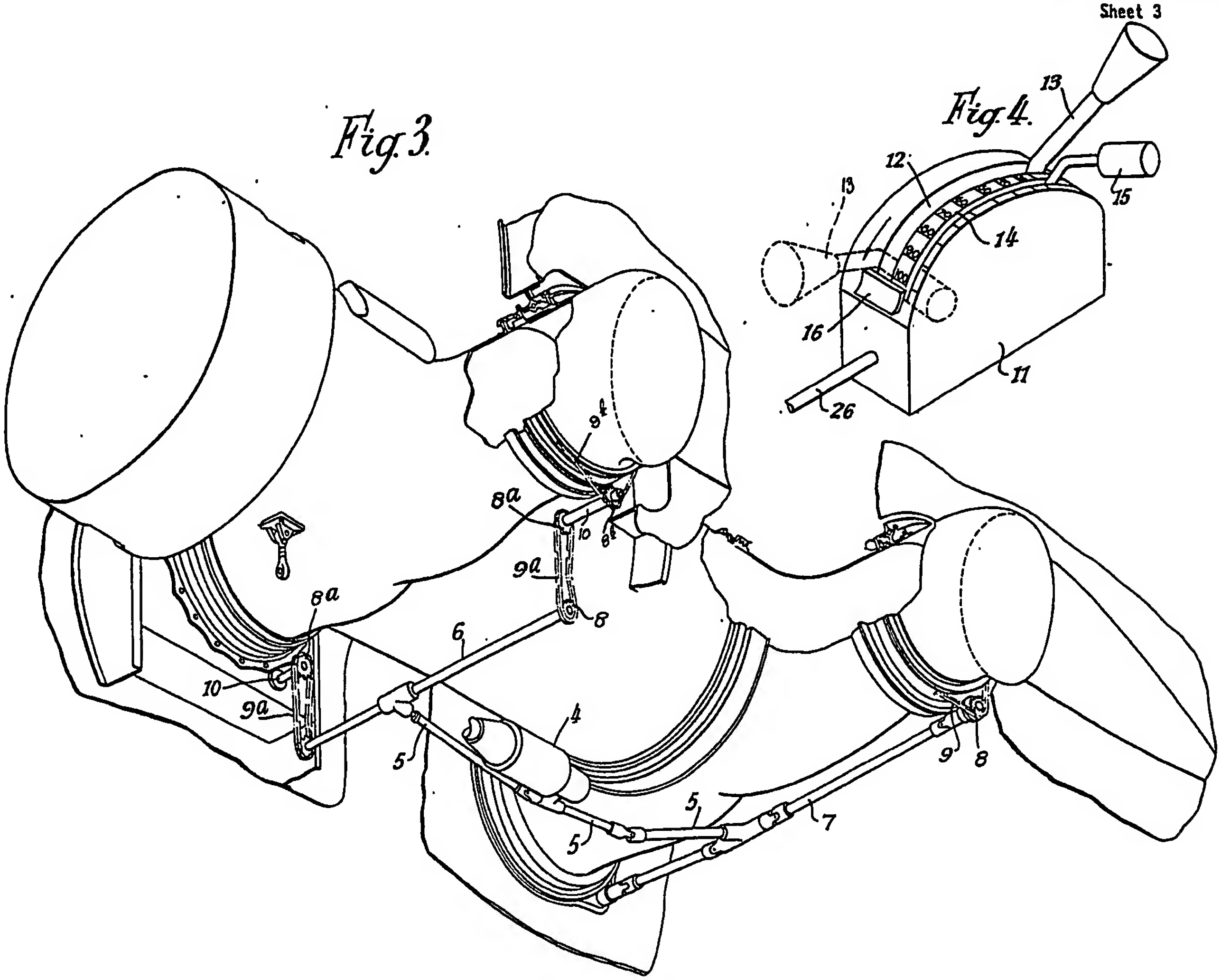

Fig. 4.